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Kinetic Models of Trymethylolpropane (TMP) and Castor Oil Methyl Ester Transesterification for Engine Oil Synthesis

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EXTENDED ABSTRACT

Non-digestible oil as renewable resources has grown a compulsive concern for engine oil synthesis. The synthesis of engine oil was conducted in a bath stirrer flask via two-steps catalytic transesterification. Modification of trimethylolpropane (TMP) and castor oil methyl ester (COME) transesterification was run under non- and impregnated *Perna V.* shells catalysts. Operation temperature effect on the castor trimethylol propane triester as engine lubricant was conditioned at range 90℃ – 130℃. The optimal reaction temperature was detected at 110℃ with 98.60 % TMP conversion and 71.29% triester composition. Excess dosage of COME was structured at 4:1 ratio to TMP for progressive reaction limitation. Kinetics of TMP and COME transesterifation were established for first- and second orders. The second order kinetic model best matchs the acquired data for an overall reaction rate constants of 0.0354 (% wt/wt min ℃)$^{-1}$. Synthesized engine oil resulted activation energy of 74.10 kJ/mol. Estimated pour and flash point were -17 ℃ and 221℃. Kinematic viscosity at 40℃ was 64.31 mm^2/s and density was 872 kg/m^3 fulfilled the proposed lubricant standard. The kinetic models were proportionate to other oil seeds crops based engine oil, typically *Jatropha* seeds oil.

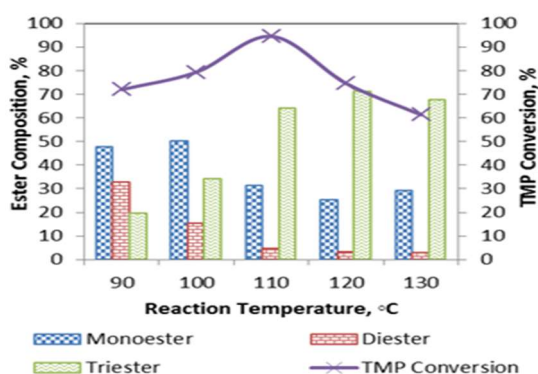Keywords: Non-digestible oil; Kinetics; *Perna V.* shells; Triester; Engine lubricant.

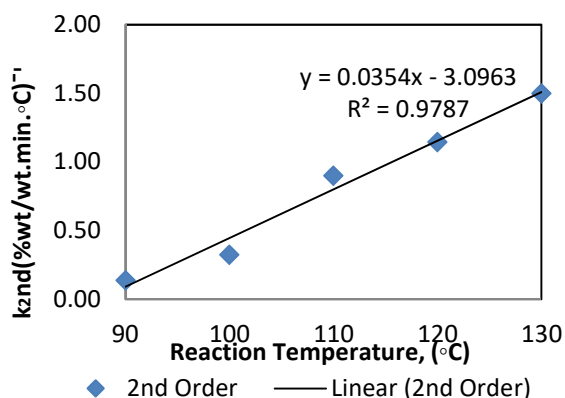Fig. 1: Operation temperature vs TMP-ester.

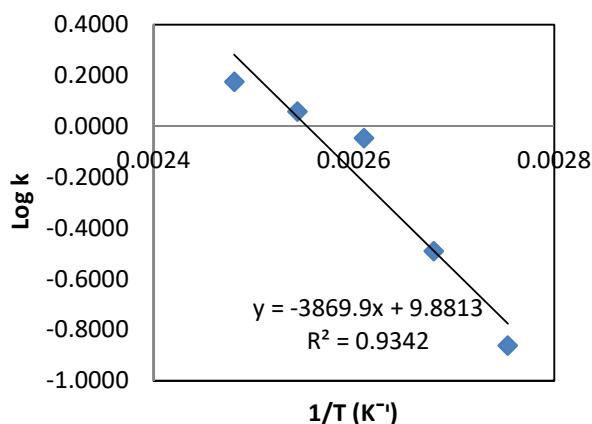Fig. 2: Overall second order kinetic model.
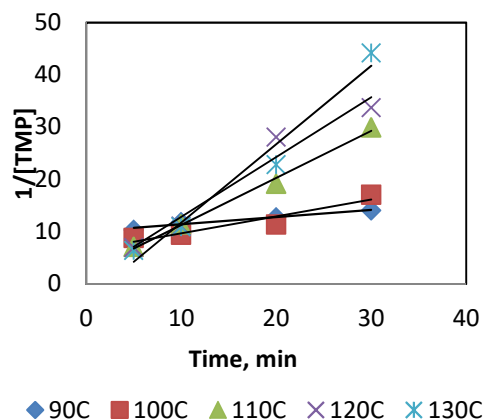
Fig. 3: Reactions rate vs temperature.

Fig. 4: Reaction time vs 1/TMP.

The usage of conventional vegetable oils as engine oil is limited due to some properties although with their excellent lubricity and viscosity index. Some undesirable lubricant properties are that the long chain fatty acids have higher melting point if saturated and poor oxidative stability when polyunsaturated [1], [2]. Otherwise, branched and monounsaturated esters such as oleates show acceptable lubricant oxidative stability and melting point. Then, vegetable oils have unpleasant smell, poor compatibility with paints. Bio-lubricants possess lower pour points than mineral oils providing excellent lubrication for cold starts [3]-[5]. In addition to that, the oxidative stability of the vegetable oil based lubricants mainly depends on the degree of unsaturated double bonds in the triglycerides as this unsaturated carbon-carbon bonds are reactive and acts as the active sites for chemical reaction mostly oxidation. The physical and chemical limitation of the vegetable oils can be improved either by genetic modification or chemical modification with suitable combination of additives [6], [7]. Castor oil as non-edible sources, has been considered to be an important commercial value for manufacturing of surfactants, coatings, methyl seter, etc. [8]. Trimethylolpropane-ester, like engine oil, etc. synthesis from the treated castor oil enables to be developed using various catalysts. Utilization of *Perna v.* shells as an alternative catalyst could be considered for biodiesel and trimethylolpropane-ester production. The *Perna v.* shells are being dumped in the landfill without any pre-treatment. The application of *Perna v.* shell had been limited to a low-cost adsorbent for metal ions extraction and desulphurization agent to remove sulphur dioxide. The constituent of *Perna* v. shell is typically calcium carbonate, it could be converted to calcium oxide. The calcium oxide of these shells can easily be recovered just by high temperature calcination in air [9]. Next, kinetic reaction model was justified to determine the effectiveness of the process. The kinetic model of the decomposition of mineral oil lubricant has been widely studied by reaserchers to determine the stability of lubricants in response to thermal effects. Unfortunately, a lack of reports about the kinetic reactions of castor oil transesterification for engine oil synthesis, esp. using solid catalysts. The experimental data was analyzed in order to understand the reaction rate by determining the rate constant of the process. An earlier kinetic study on transestrification of biolubricant stated that the rate constant was directly proportional with temperature [10]-[12]. Thus, this work evaluates the kinetic model of trimethylolpropane and castor oil methyl ester (COME) transesterification for engine oil synthesis. Modification of trimethylolpropane (TMP) and COME transesterification was run under non- and impregnated *Perna V.* shells catalysts via two-steps catalytic transesterification in a bath stirrer flask. Operation temperature effect on the castor trimethylol propane triester as engine lubricant was conditioned at range 90℃ – 130℃. The reaction time and rate, temperature effects and overal second order kinetic model can be shown in the Fig. 1, 2, 3 and 4.

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